

# **STRUCTURAL ENGINEERING I & II**

**OVERVIEW:** TSA teams entering the Structural Engineering event will construct a test model of the selected structure, which will be destructively tested to determine design efficiency. Design type and dimensions will be provided by the Event Consultant. This is a National Event.

**I. CONTEST PURPOSE**

The purpose of the Structural Engineering event is to provide a means for TSA members to demonstrate their ability to design and construct a model structure from the provided material, within the allowed time as a team.

**II. ELIGIBILITY FOR ENTRY**

- A. Must be current TSA state and national member and registered State Conference participant.
- B. This is a team event. A team consists of two members. Each chapter may enter up to four (4) teams, one of which may consist of 1 member, not to exceed 8 members per chapter.
- C. Team members must be from the same TSA chapter.

**III. LIMITATIONS**

- A. All participants in this event must arrive and be "in place" at the specified time and location.
- B. All work must be finished and checked in during the two hours allowed for design and construction.
- C. The time will start when the type and dimensions of the structure are given.
- D. Participants with conflicts must present a written explanation of their conflict to the Event Consultant for approval, one hour prior to the start time printed in the conference schedule. Work must start during the time scheduled for the event.

**IV. SPECIFIC REGULATIONS**

- A. National rules may differ from state rules. Individuals planning on participating in national competition must adhere to national rules.
- B. All work will be done by the team in the specified area, and within the time specified by the judges.
- C. The structure will consist of 1/8" by 1/8" balsa, glue, and the tower base, if provided. Only material provided during the event may be used. Tools provided for construction may not be used as part of the structure, and must be removed before check-in (see required materials for specific list.)
- D. A section of the structure must be completed on the provided graph paper before cutting and/or construction begins.

- E. The type of structure will be selected by the Event Consultant, by random drawing from the following list.

1. Bridge with superstructure above the roadbed only.
2. Bridge with structure below and/or above the roadbed.
3. Tower.
4. Truss (Level II competition only).

NOTE: The structure drawn for the event will be eliminated from the list for next year.

- F. The size of the structure will be selected by the Event Consultant following the random drawing for the type of structure. The dimensions drawn will be within the following range:

1. Bridge with superstructure above the roadbed for a span between 8" and 18".
2. Bridge with superstructure above and/or below the roadbed will draw for a span of between 8" and 18".
3. Tower will draw for a height of between 12" and 18".
4. Truss will draw for a structure between 12" and 18".
5. All types of structures may use gusset material. Balsa 1/8" x 1/8" x 3/8" maximum size.

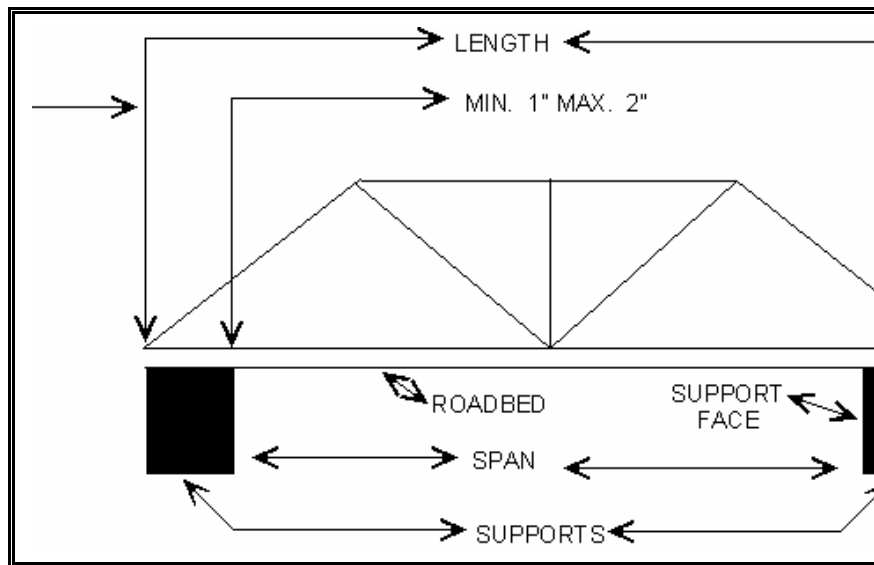
- G. Specific Definitions

1. Applies to all structures
  - a. Lamination: two pieces of 1/8" by 1/8" balsa glued together, surface to surface, with the grain running parallel. Lamination of more than two pieces is not permitted.



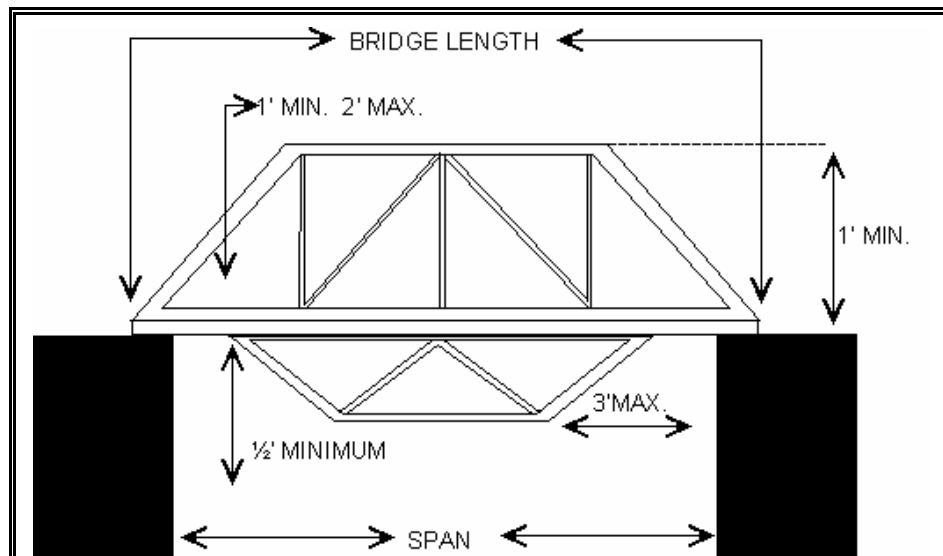
- b. Failure weight: the greatest weight recorded during testing to failure of the structure.
  - c. Failure to comply: if a structure fails to comply with any specific definition, the structure will be disqualified.

2. Applies to the Figure 1 bridge with superstructure above the roadbed only, and the Figure 2 bridge with structure below and/or above the roadbed.
  - a. Bridge length: the length of the bridge is to include the span plus 2", but not to exceed the span plus 4". The additional length is to be used to hold the bridge on the test device on each end of the bridge, and may not be less than 1" per side or greater than 2" inches per side.
  - b. Superstructure: any part of the bridge that extends above or below the roadbed.
    - (1) Applies to a bridge with a superstructure above the roadbed
      - (a) The superstructure must extend at least 1" above the roadbed.
      - (b) The superstructure may extend beyond the 1" above the roadbed.



**Figure 1. Bridge with superstructure above the roadbed only**

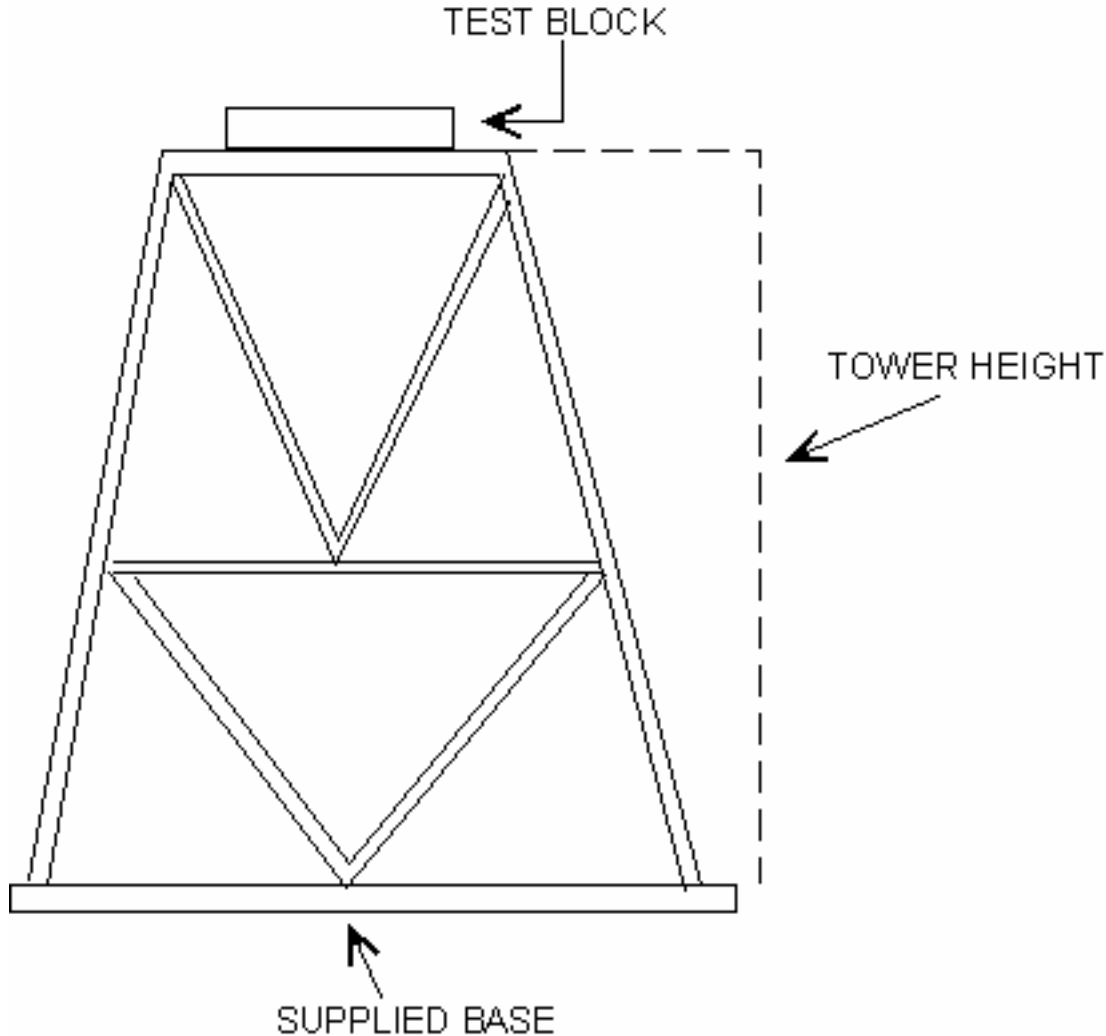
3. Applies to the Figure 2 bridge with structure below and/or above the roadbed.
  - a. The superstructure must extend at least 1" above the roadbed.
  - b. The superstructure may extend beyond 1" above the roadbed.
  - c. The superstructure must extend at least 1" below and/or above the roadbed.
  - d. A superstructure below must maintain  $\frac{1}{2}$  " clearance from the face of the test device at the beginning of testing.
  - e. A superstructure below the roadbed may not extend beyond 3" from the bottom of the roadbed.



**Figure 2. Bridge with a superstructure above and/or below the roadbed**

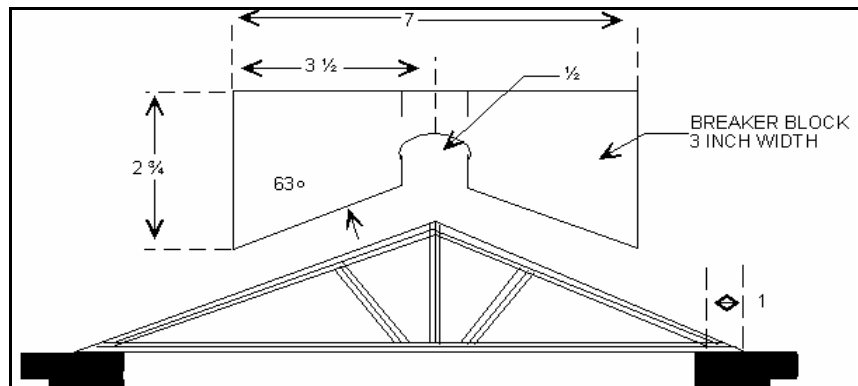
- f. Span: the distance between the bridge supports. This measurement will be selected at random at the beginning of the event.
- g. Failure: failure is determined by:
  - (1) the bridge collapsing from the load placed on the test block by the testing device, or
  - (2) the superstructure below the roadbed that touches the face of the testing device.
- h. Roadbed: the part of the bridge that is meant to be traveled on.
  - (1) The roadbed will extend the full length of the bridge without obstruction and maintain a width of at least 3".
  - (2) The roadbed may not be more than 1/4" thick.
  - (3) A block 1" thick and 3" wide will be passed through the bridge to determine if (1) is in compliance.
  - (4) With the block in place the roadbed will be checked for compliance with (2).

**Figure 3. Tower**



- a. Height: the vertical measurement from the bottom of the tower base to top of the tower where the testing block will be placed. This is the measurement that will be selected at random at the beginning of the event.
- b. Failure: the tower is considered to have failed when:
  - (1) the test block has dropped two inches,
  - (2) the support for test block has separated from the tower sides,
  - or,
  - (3) a tower binds on the test hook during failure.
- c. Test Hook: the center of the tower must be clear to accommodate a test hook to be secured to a 3" by 3" square block placed on top of the tower. A space of 1" diameter concentric to  $\frac{1}{2}$ " hole in the tower base must be clear to accommodate the test hook. A design that binds on the test hook will be considered as failed when any part of the tower touches the test hook.
- d. Width: the tower sides may not extend beyond the vertical edges of the tower base. All support of the tower should originate from the base.

**Figure 4. Truss**



- (1) The structure: a residential style roof truss with 1" of rise for every 2" of run.
- (2) The length of the truss is a random number drawn by the Event Consultant.
- (3) The height of the truss is one-fourth of the length.
- (4) The width of the truss is between 2 1/2 " and 4".
- (5) No part of the truss may extend below the horizontal plane of the testing device.
- (6) The peak of the truss is centered in the length of the truss.
- (7) One inch (1") of each end rests on the tester.
- (8) The truss must be a complete triangle. The breaker accommodates a pitch of 1" of rise to every 2" of run.

**V. REQUIRED EVENT PERSONNEL**

A. Event Coordinator.

B. Construction Monitors.

1. A minimum of one to twenty teams, per level.
2. A time keeper.

C. Judges - three per level to qualify structure following construction.

D. Breaking judges.

1. One per level to position structure on testing device.
2. One per level to weigh structure and record weight.
3. One per level to record failure weight.
4. One per level to bring structure to testing location.
5. One per level to remove and store structure following testing.

## VI. REQUIRED MATERIALS

- A. Required tools and supplies. All tools and supplies will be provided at the event. No substitutions or alternate tools will be permitted. Any special needs will be addressed by the Event Consultant before the beginning of check-in.

### 1. Construction.

#### a. Tools - to be returned after construction

- (1) cutting device
  - (a) single edge razor
  - (b) modeling knife
- (2) pin board - 1' by 1' fiber board
- (3) cutting board - 1' by 1' masonite
- (4) ruler
- (5) straight pins
- (6) clothes pins - spring style

#### b. Supplies - to be used to make the structure

- (1) 21 feet – 1/8" x 1/8" balsa
- (2) colored adhesive - Aliphatic resin
- (3) tower base - 4" by 4" square of 1/4" plywood with a 1/2" hole drilled in the center
- (4) grid paper - 1/4" by 1/4" grid on 11" by 17" paper for the sketch of the structure

- B. Testing equipment - the testing equipment will provide a downward pull that will record the peak force until the structure fails.

### 1. For a bridge.

- a. A block 2" wide by 3/4" thick and 2" less than the span, will be centered in the bridge and centered between the bridge supports.
- b. The block will have a hole centered for the attachment of the testing device.
- b. Bridges which have members blocking the placement of the testing line, will not be tested.

### 2. For a tower.

- a. The base will be clamped into a testing device, and a line will pass through the 1/2" hole, centered in the 3" by 3" block, resting on the top of the tower.
- c. Towers which have members blocking the placement of the testing line, will not be tested.



- C. Evaluation and recording equipment.
  - 1. Gram scale.
  - 2. Tape measure or 2' ruler.
  - 3. Evaluation gauges.
  - 4. Calculator or computer to perform calculations.
  - 5. Evaluation forms - as provided by the Event Consultant, one per entry.

## VII. SITE REQUIREMENTS

- A. Construction session.
  - 1. Tables and chairs suitable for cutting and gluing.
  - 2. Each team should have at least 2' by 3' of work area (suggested space is two teams on 6' by 2' tables or 8' by 2' tables).
  - 3. Tables for equipment check-out and check-in.
  - 4. Tables and chairs for judges.
  - 5. Area securable for drying of entries and storage of supplies.
- B. Testing session.
  - 1. Tables for storage of structures.
  - 2. Tables for weighing - one per level.
  - 3. Tables for testing - one per level.
  - 4. Tables for recording - one per level.
  - 5. Tables for storage of failed structures.
  - 6. Chairs for spectators.
  - 7. Barricade to separate testing area and spectators.

## VIII. TESTING

- A. The structure will be weighed before testing, and the weight recorded on the evaluation form.
- B. An increasing load will be applied to the structure, until the structure fails.
- C. The failure weight will be recorded on the evaluation form.
- D. The efficiency will be determined by the following formula:  
  
**$$\text{Failure weight (in lbs)} \times 453.6 \text{ (grams/lbs)} \div \text{Weight of structure (grams)} = \text{Efficiency}$$**
- E. The Efficiency will be rounded off to three decimal places and recorded on the evaluation form.
- F. The highest numeric Efficiency is the winner.